



GLOBAL
EDITION



Statistics

Informed Decisions Using Data

FIFTH EDITION

Michael Sullivan

 Pearson

Sullivan's Guide to Putting It Together

Putting It Together Sections	Objective	Page(s)	
5.6 Putting It Together: Which Method Do I Use?	<ol style="list-style-type: none"> 1 Determine the appropriate probability rule to use 2 Determine the appropriate counting technique to use 	330–331 331–333	
9.5 Putting It Together: Which Method Do I Use?	<ol style="list-style-type: none"> 1 Determine the appropriate confidence interval to construct 	483–484	
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5.1.54 Drug Side Effects	Variables, graphical summaries of data, experiments, probability	1.1, 1.6, 2.1, 5.1	289
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5.2.45 Red Light Cameras	Variables, relative frequency distributions, bar graphs, mean, standard deviation, probability, Simpson's Paradox	1.1, 2.1, 3.1, 3.2, 4.4, 5.1, 5.2	300–301
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9.1.47 Hand Washing	Observational studies, bias, confidence intervals	1.2, 1.5, 9.1	462
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10.2.39 Naughty or Nice?	Experimental design, determining null and alternative hypotheses, binomial probabilities, interpreting P -values	1.6, 6.2, 10.1, 10.2	521

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Putting It Together Exercises	Skills Utilized	Section(s) Covered	Page(s)
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11.2.18 Glide Testing	Matched pairs design, hypothesis testing	1.6, 11.2	574
11.3.23 Online Homework	Completely randomized design, confounding, hypothesis testing	1.6, 11.3	585–586
12.1.27 The V-2 Rocket in London	Mean of discrete data, expected value, Poisson probability distribution, goodness-of-fit	6.1, 6.3, 12.1	619
12.1.28 Weldon's Dice	Addition Rule for Disjoint Events, classical probability, goodness-of-Fit	5.1, 5.2, 12.1	619
12.2.21 Women, Aspirin, and Heart Attacks	Population, sample, variables, observational study vs. designed experiment, experimental design, compare two proportions, chi-square test of homogeneity	1.1, 1.2, 1.6, 11.1, 12.2	634
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Updated for this edition is the Student Activity Workbook. The Activity Workbook includes many tactile activities for the classroom. In addition, the workbook includes activities based on statistical applets. Below is a list of the applet activities.

Applet	Section	Activity Name
Mean versus Median	3.1	Understanding Measures of Center
Standard Deviation	3.2	Exploring Standard Deviation
Correlation by Eye	4.1	Exploring Properties of the Linear Correlation Coefficient
Regression by Eye	4.2	Minimizing the Sum of the Squared Residuals
Regression Influence	4.3	Understanding Influential Observations
Rolling a Single Die	5.1	Demonstrating the Law of Large Numbers
Binomial Distribution	6.2	Exploring a Binomial Distribution from Multiple Perspectives
Baseball Applet	6.2	Using Binomial Probabilities in Baseball
Sampling Distributions	8.1	Sampling from Normal and Non-normal Populations
Sampling Distributions Binary	8.2	Describing the Distribution of the Sample Proportion
Confidence Intervals for a Proportion	9.1	Exploring the Effects of Confidence Level, Sample Size, and Shape I
Confidence Intervals for a Mean	9.2	Exploring the Effects of Confidence Level, Sample Size, and Shape II
Political Poll Applet	10.2	The Logic of Hypothesis Testing
Hypothesis Tests for a Proportion	10.2	Understanding Type I Error Rates
Cola Applet	10.2	Testing Cola Preferences
Hypothesis Tests for a Mean	10.3	Understanding Type I Error Rates
Randomization Test Warts	11.1	Making an Inference about Two Proportions
Randomization Test Basketball	11.2	Predicting Basketball Game Outcomes
Randomization Test Sentence	11.2	Considering the Effects of Grammar
Randomization Test Kiss	11.2	Analyzing Kiss Data
Randomization Test Algebra	11.3	Using Randomization Test for Independent Means
Randomization Test Market	11.3	Comparing Bull and Bear Markets
Randomization Test Zillow	14.1	Using a Randomization Test for Correlation
Randomization Test Brain Size	14.1	Using a Randomization Test for Correlation

STATISTICS

INFORMED DECISIONS USING DATA

Fifth Edition

Global Edition

Michael Sullivan, III

Joliet Junior College



Pearson

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To My Wife Yolanda
and My Children
Michael, Kevin, and Marissa

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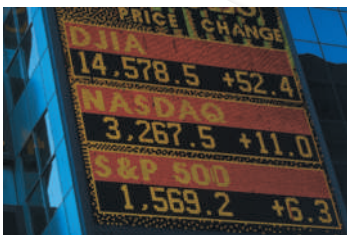
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Preface to the Instructor

Capturing a Powerful and Exciting Discipline in a Textbook

Statistics is a powerful subject, and it is one of my passions. Bringing my passion for the subject together with my desire to create a text that would work for me, my students, and my school led me to write the first edition of this textbook. It continues to motivate me as I reflect on changes in students, in the statistics community, and in the world around us.

When I started writing, I used the manuscript of this text in class. My students provided valuable, insightful feedback, and I made adjustments based on their comments. In many respects, this text was written by students and for students. I also received constructive feedback from a wide range of statistics faculty, which has refined ideas in the book and in my teaching. I continue to receive valuable feedback from both faculty and students, and this text continues to evolve with the goal of providing clear, concise, and readable explanations, while challenging students to think statistically.

In writing this edition, I continue to make a special effort to abide by the Guidelines for Assessment and Instruction in Statistics Education (GAISE) for the college introductory course endorsed by the American Statistical Association (ASA). The GAISE Report gives six recommendations for the course:

1. Emphasize statistical literacy and develop statistical thinking
2. Use real data in teaching statistics
3. Stress conceptual understanding
4. Foster active learning
5. Use technology for developing conceptual understanding
6. Use assessments to improve and evaluate student learning

Changes to this edition and the hallmark features of the text reflect a strong adherence to these important GAISE guidelines.

Putting It Together

When students are learning statistics, often they struggle with seeing the big picture of how it all fits together. One of my goals is to help students learn not just the important concepts and methods of statistics but also how to put them together.

On the inside front cover, you'll see a pathway that provides a guide for students as they navigate through the process of learning statistics. The features and chapter organization in the fifth edition reinforce this important process.

New to This Edition

- **Over 350 New and Updated Exercises** The fifth edition makes a concerted effort to require students to write a few sentences that explain the results of their statistical

analysis. To reflect this effort, the answers in the back of the text provide recommended explanations of the statistical results. In addition, exercises have been written to require students to understand pitfalls in faulty statistical analysis.

- **Over 100 New and Updated Examples** The examples continue to engage and provide clear, concise explanations for the students while following the Problem, Approach, Solution presentation. Problem lays out the scenario of the example, Approach provides insight into the thought process behind the methodology used to solve the problem, and Solution goes through the solution utilizing the methodology suggested in the approach.
- **Videos** The suite of videos available with this edition has been extensively updated. Featuring the author and George Woodbury, there are both instructional videos that develop statistical concepts and example videos. Most example videos have both by-hand solutions and technology solutions (where applicable). In addition, each Chapter Test problem has video solutions available.
- **Retain Your Knowledge** A new problem type. The Retain Your Knowledge problems occur periodically at the end of section exercises. These problems are meant to assist students in retaining skills learned earlier in the course so that the material is fresh for the final exam.
- **Big Data Problems** Data is ubiquitous today. The ability to collect data from a variety of sources has resulted in very large data sets. While analysis of data sets with tens of thousands of observations with thousands of variables is not practical at the introductory level, it is important for students to analyze data sets with more than fifty observations. These problems are marked with a 📊 icon and the data is available at www.pearsonglobaleditions.com/sullivan.
- **Technology Help in MyStatLab** Problems in MyStatLab that may be analyzed using statistical packages now have an updated technology help feature. Marked with a ? icon, this feature provides step-by-step instructions on how to obtain results using StatCrunch, TI-84 Plus/TI-84 Plus C, and Excel.
- **Instructor Resource Guide** The Instructor Resource Guide provides an overview of the chapter. It also details points to emphasize within each section and suggestions for presenting the material. In addition, the guide provides examples that may be used in the classroom.

Hallmark Features

- **Student Activity Workbook** The updated activity workbook contains many in-class activities that may be used to enhance your students' conceptual understanding of statistical concepts. The activities involve many tactile and applet-based simulations. Applets for the activities may be found at www.pearsonglobaleditions.com/sullivan. In addition, the activity workbook

includes many exercises that introduce **simulation** and **randomization methods** for statistical inference.

- Chapter 10 has simulation techniques that are powerful introductions to the logic of hypothesis testing. There are two activities that utilize simulation techniques. It also contains an activity on using Bootstrapping to test hypotheses for a single mean.
- Chapter 11 has randomization techniques for analyzing the difference of two proportions and the difference of two means. There are four activities for analyzing the difference of two proportions and two activities for analyzing the difference of two means.
- Chapter 14 has randomization techniques for analyzing the strength of association between two quantitative variables. There are two activities for a randomization test for correlation.

The workbook is accompanied by an instructor resource guide with suggestions for incorporating the activities into class.

- Because the use of **Real Data** piques student interest and helps show the relevance of statistics, great efforts have been made to extensively incorporate real data in the exercises and examples.
- **Putting It Together** sections appear in Chapters 5, 9, 10, and 11. The problems in these sections are meant to help students identify the correct approach to solving a problem. Many new exercises have been added to these sections that mix in inferential techniques from previous sections. Plus, there are new problems that require students to identify the inferential technique that may be used to answer the research objective (but no analysis is required). For example, see Problems 23 to 29 in Section 10.5.
- **Step-by-Step Annotated Examples** guide a student from problem to solution in three easy-to-follow steps.
- “**Now Work**” problems follow most examples so students can practice the concepts shown.
- Multiple types of **Exercises** are used at the end of sections and chapters to test varying skills with progressive levels of difficulty. These exercises include **Vocabulary and Skill Building**, **Applying the Concepts**, and **Explaining the Concepts**.
- **Chapter Review** sections include:
 - **Chapter Summary**.
 - A list of key chapter **Vocabulary**.
 - A list of **Formulas** used in the chapter.
 - **Chapter Objectives** listed with corresponding review exercises.
 - **Review Exercises** with all answers available in the back of the book.
 - **Chapter Test** with all answers available in the back of the book. In addition, the Chapter Test problems have **video solutions** available.
- Each chapter concludes with **Case Studies** that help students apply their knowledge and promote active learning.

Integration of Technology

This book can be used with or without technology. Should you choose to integrate technology in the course, the following resources are available for your students:

- Technology Step-by-Step guides are included in applicable sections that show how to use Minitab®, Excel®, the TI-83/84, and StatCrunch to complete statistics processes.
- Any problem that has 12 or more observations in the data set has a 📊 icon indicating that data set is included on the companion website (www.pearsonglobaleditions.com/sullivan) in various formats. Any problem that has a very large data set that is not printed in the text has a 📈 icon, which also indicates that the data set is included on the companion website. These data sets have many observations and often many variables.
- Where applicable, exercises and examples incorporate output screens from various software including Minitab, the TI-83/84 Plus C, Excel, and StatCrunch.
- Twenty new Applets are included on the companion website and connected with certain activities from the Student Activity Workbook, allowing students to manipulate data and interact with animations. See the front inside cover for a list of applets.
- Accompanying Technology Manuals are available that contain detailed tutorial instructions and worked out examples and exercises for the TI-83/84 and 89 and Excel.

Companion Website Contents

- Data Sets
- Twenty new Applets
- Formula Cards and Tables in PDF format
- Additional Topics Folder including:
 - Sections 4.5, 5.7, and 6.4
 - Appendix A and Appendix B
- A copy of the questions asked on the Sullivan Statistics Survey I and Survey II
- Consumer Reports projects that were formerly in the text

Key Chapter Content Changes

Chapter 1 Data Collection

The chapter now includes an expanded discussion of confounding, including a distinction between lurking variables and confounding variables.

Chapter 4 Describing the Relation between Two Variables

Section 4.3 now includes a brief discussion of the concept of leverage in the material on identifying influential observations. The conditional bar graphs in Section 4.4 have been drawn so that each category of the explanatory

variable is grouped. This allows the student to see the complete distribution of each category of the explanatory variable. In addition, the material now includes stacked (or segmented) conditional bar graphs.

Chapter 6 Discrete Probability Distributions

The graphical representation of discrete probability distributions no longer is presented as a probability histogram. Instead, the graph of a discrete probability distribution is presented to emphasize that the data is discrete. Therefore, the graph of discrete probability distributions is drawn using vertical lines above each value of the random variable to a height that is the probability of the random variable.

Chapter 7 The Normal Probability Distribution

The assessment of normality of a random variable using normal probability plots has changed. We no longer rely on normal probability plots drawn using Minitab. Instead, we utilize the correlation between the observed data and normal scores. This approach is based upon the research of S.W. Looney and T. R. Gullledge in their paper, “Use of the Correlation Coefficient with Normal Probability Plots,” published in the *American Statistician*. This material may be skipped without loss of continuity (especially for those who postponed the material in Chapter 4). Some problems from Chapter 9 through 13 may need to be skipped or edited, however.

Chapter 9 Estimating the Value of a Parameter

The Putting It Together section went through an extensive renovation of the exercises. Emphasis is placed on identifying the variable of interest in the study (in particular, whether the variable is qualitative or quantitative). In addition, there are problems that simply require the student to identify the type of interval that could be constructed to address the research concerns.

Chapter 10 Hypothesis Testing Regarding a Parameter

The Putting It Together section went through an extensive revision. Again, emphasis is placed on identifying the variable of interest in the study. The exercises include a mix of hypothesis tests and confidence intervals. Plus, there are problems that require the student to identify the type of inference that could be constructed to address the research.

Chapter 11 Inference on Two Samples

The material on inference for two dependent population proportions is now covered in Section 12.3 utilizing the chi-square distribution. As in Chapter 9 and Chapter 10, the Putting It Together section’s exercises were revised extensively. There is a healthy mix of two-sample and single-sample analysis (both hypothesis tests and confidence intervals). This will help students to develop the ability to determine the type of analysis required for a given research objective.

Chapter 12 Inference on Categorical Data

In Section 12.2, we now emphasize how to distinguish between the chi-square test for independence and the chi-square test for homogeneity of proportions. The material on inference for two dependent proportions formerly in Section 11.1 is now a stand-alone Section 12.3 so that we might use chi-square methods to analyze the data.

Chapter 13 Comparing Three or More Means

The Analysis of Variance procedures now include construction of normal probability plots of the residuals to verify the normality requirement.

Chapter 14 Inference on the Least-Squares Regression Model and Multiple Regression

Section 14.3 Multiple Regression from the fourth edition has been expanded to four sections. The discussion now includes increased emphasis on interaction, dummy variables, and polynomial regression. Building regression models is now its own section and includes stepwise, forward, and backward regression model building.

Flexible to Work with Your Syllabus

To meet the varied needs of diverse syllabi, this book has been organized to be flexible.

You will notice the “Preparing for This Section” material at the beginning of each section, which will tip you off to dependencies within the course. The two most common variations within an introductory statistics course are the treatment of regression analysis and the treatment of probability.

- **Coverage of Correlation and Regression** The text was written with the descriptive portion of bivariate data (Chapter 4) presented after the descriptive portion of univariate data (Chapter 3). Instructors who prefer to postpone the discussion of bivariate data can skip Chapter 4 and return to it before covering Chapter 14. (Because Section 4.5 on nonlinear regression is covered by a select few instructors, it is located on the website that accompanies the text in Adobe PDF form, so that it can be easily printed.)
- **Coverage of Probability** The text allows for light to extensive coverage of probability. Instructors wishing to minimize probability may cover Section 5.1 and skip the remaining sections. A mid-level treatment of probability can be accomplished by covering Sections 5.1 through 5.3. Instructors who will cover the chi-square test for independence will want to cover Sections 5.1 through 5.3. In addition, an instructor who will cover binomial probabilities will want to cover independence in Section 5.3 and combinations in Section 5.5.

Acknowledgments

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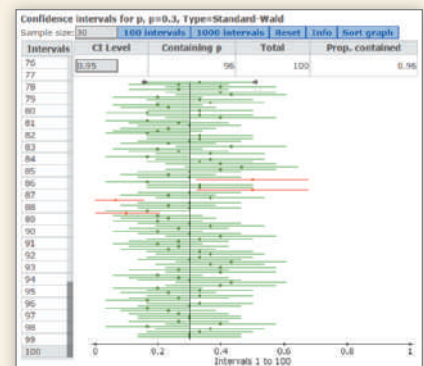
1. If necessary, enter the summarized data into the spreadsheet. Name the columns.
2. Select **Stat**, highlight **Summary Stats**, and select **Grouped/Binned data**.
3. Choose the column that contains the class under the "Bins in:" drop-down menu. Choose the column that contains the frequencies in the "Counts in:" drop-down menu. Select the "Consecutive lower limits" radio button for defining the midpoints. Click **Compute!**.

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New! Instructor's Guide for Student Activity Workbook (Download only)

by Heather Foes and Kathleen Almy, *Rock Valley College* and Michael Sullivan, III, *Joliet Junior College*. Accompanies the activity workbook with suggestions for incorporating the activities into class. The Guide is available from the Instructor's Resource Center and MyStatLab.

New! Instructor's Resource Guide (Download only)

by Michael Sullivan, III, *Joliet Junior College*.

This guide presents an overview of each chapter along with details about concepts that should be emphasized for each section. The resource guide also provides additional examples (complete with solutions) for each section that may be used for classroom presentations. This Guide is available from the Instructor's Resource Center and MyStatLab.

Student Resources

New! Author in the Classroom Videos

by Michael Sullivan, III, *Joliet Junior College* and George Woodbury, *College of the Sequoias*

The suite of videos available with this edition has been extensively updated. Featuring the author and George Woodbury, there are both instructional videos that develop statistical concepts and example videos. Most example videos have both by-hand solutions and technology solutions (where applicable). In addition, each Chapter Test problem has video solutions available.

Technology Manuals

The following technology manuals contain detailed tutorial instructions and worked-out examples and exercises.

- **Excel Manual (including XLSTAT)** by Alana Tuckey, *Jackson Community College*
- **Graphing Calculator Manual for the TI-83/84 Plus and TI-89** by Kathleen McLaughlin and Dorothy Wakefield

New! Student Activity Workbook

by Heather Foes and Kathleen Almy, *Rock Valley College*, and Michael Sullivan, III, *Joliet Junior College*

(ISBN 13: 978-0-13-411610-5; ISBN 10: 0-13-411610-0)

Includes classroom and applet activities that allow students to experience statistics firsthand in an active learning environment. Also introduces resampling methods that help develop conceptual understanding of hypothesis testing.

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PART

1

Getting the Information You Need

CHAPTER 1

Data Collection

Statistics is a process—a series of steps that leads to a goal. This text is divided into four parts to help the reader see the process of statistics.

Part 1 focuses on the first step in the process, which is to determine the research objective or question to be answered. Then information is obtained to answer the questions stated in the research objective.

1

Data Collection

Outline

- 1.1 Introduction to the Practice of Statistics
- 1.2 Observational Studies versus Designed Experiments
- 1.3 Simple Random Sampling
- 1.4 Other Effective Sampling Methods
- 1.5 Bias in Sampling
- 1.6 The Design of Experiments

Making an Informed Decision



It is your senior year of high school. You will have a lot of exciting experiences in the upcoming year, plus a major decision to make—which college should I attend? The choice you make may affect many aspects of your life—your career, where you live, your significant other, and so on, so you don't want to simply choose the college that everyone else picks. You need to design a questionnaire to help you make an informed decision about college. In addition, you want to know how well the college you are considering educates its students. See *Making an Informed Decision* on page 87.

PUTTING IT TOGETHER

Statistics plays a major role in many aspects of our lives. It is used in sports, for example, to help a general manager decide which player might be the best fit for a team. It is used in politics to help candidates understand how the public feels about various policies. And statistics is used in medicine to help determine the effectiveness of new drugs.

Used appropriately, statistics can enhance our understanding of the world around us. Used inappropriately, it can lend support to inaccurate beliefs. Understanding statistical methods will provide you with the ability to analyze and critique studies and the opportunity to become an informed consumer of information. Understanding statistical methods will also enable you to distinguish solid analysis from bogus “facts.”

To help you understand the features of this text and for hints to help you study, read the *Pathway to Success* on the front inside cover of the text.